



National Aeronautics and  
Space Administration

**Jet Propulsion Laboratory**  
California Institute of Technology  
Pasadena, California

*Atmospheric Infrared Sounder*

# AIRS CO<sub>2</sub> in the Upper Troposphere

**Xun Jiang, Moustafa T. Chahine, Qinbin Li, Edward T. Olsen,  
Luke Chen, Danie Liang, Runlie Shia, and Yuk Yung**

*Jet Propulsion Laboratory  
California Institute of Technology*

**3/28/2007**



National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

*Atmospheric Infrared Sounder*

# Overview

- Motivation
- Validation of AIRS CO<sub>2</sub> and O<sub>3</sub> with Aircraft and Ozoneprobe Data
- Stratospheric Sudden Warming Influence on CO<sub>2</sub> and O<sub>3</sub>
- Model Comparisons



National Aeronautics and  
Space Administration

**Jet Propulsion Laboratory**  
California Institute of Technology  
Pasadena, California

*Atmospheric Infrared Sounder*

# Motivation

- Trace gases from AIRS offer a unique opportunity to test chemical/transport/dynamical models
- Improve our understanding of stratosphere-troposphere exchange and vertical transport in the models



National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

*Atmospheric Infrared Sounder*

# Data

- AIRS CO<sub>2</sub> and O<sub>3</sub> in Upper Troposphere
- Aircraft Data of CO<sub>2</sub> from Matsueda *et al.* [2002] and Climate Monitoring & Diagnostics Laboratory (CMDL)
- Ozonesonde data from World Ozone and Ultraviolet Data (WOUDC)

# Models

- 2-D Caltech/JPL Chemistry and Transport Model (CTM)
  - 10° (latitude); 40 vertical levels
  - Transport: NCEP and UKMO Reanalysis Data
  - Boundary condition: CMDL CO<sub>2</sub>
  
- 3-D GEOS-CHEM Model
  - 2° (latitude) x 2.5° (longitude), 30 vertical levels
  - Transport: GEOS-4 Meteorological Data  
GEOS-3 Meteorological Data
  - Boundary condition: CMDL CO<sub>2</sub>  
CO<sub>2</sub> surface sources and sinks
  
- MOZART2
  - Transport: MACCM3
  - Boundary condition: CMDL CO<sub>2</sub>

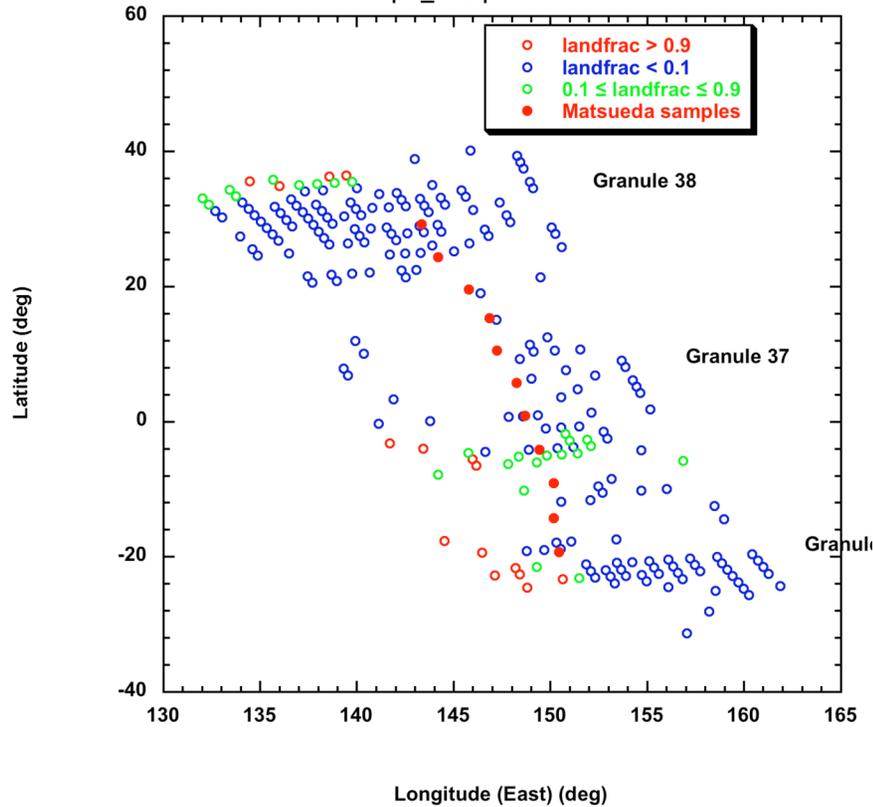


National Aeronautics and  
Space Administration  
  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

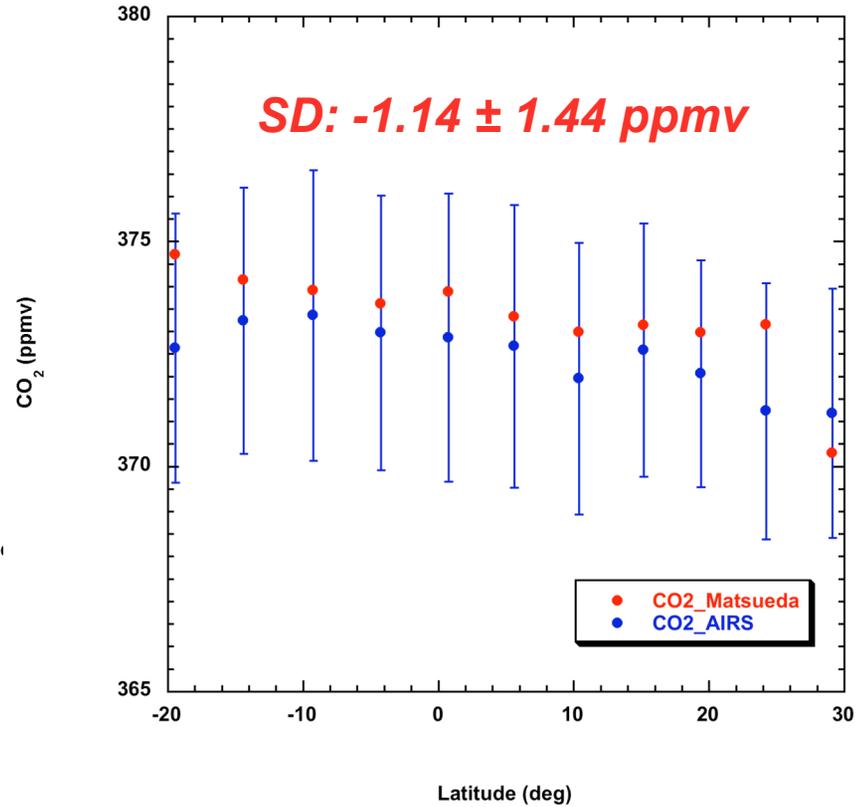
Atmospheric Infrared Sounder

# Comparison Between AIRS CO<sub>2</sub> with Matsueda Aircraft Data

01Oct03 Matchups  
Matsueda and Collocated AIRS Clusters  
Clusters are intersection if INIT=373 and 380  
|dr\_max| = 1500 km



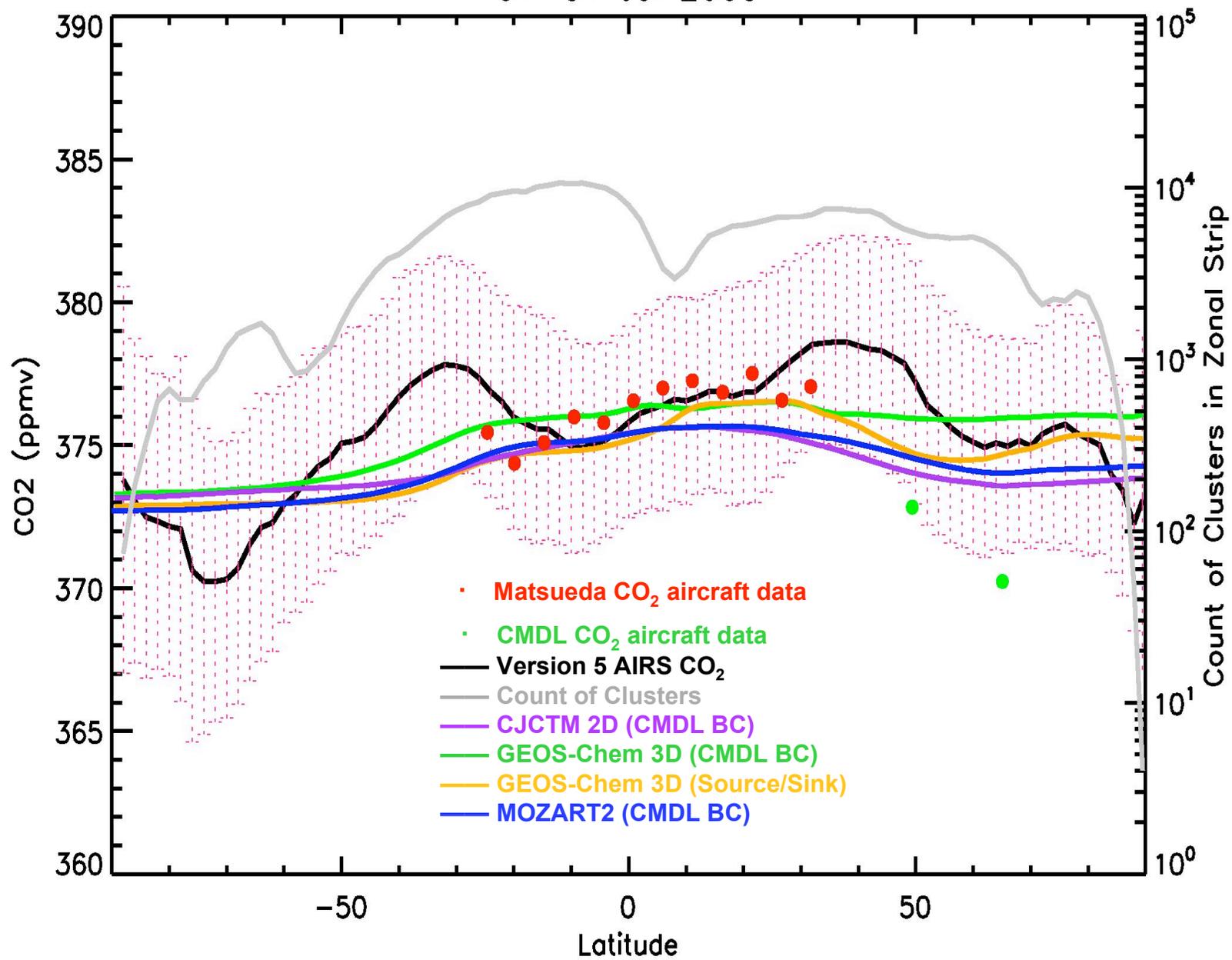
01Oct03 Matchups  
AIRS Retrievals are average of INIT=373 and 380  
Clusters within 1500 km of Matsueda  
(variable O3 alpha)  
(Error Bars are +/- StdDev of Average)



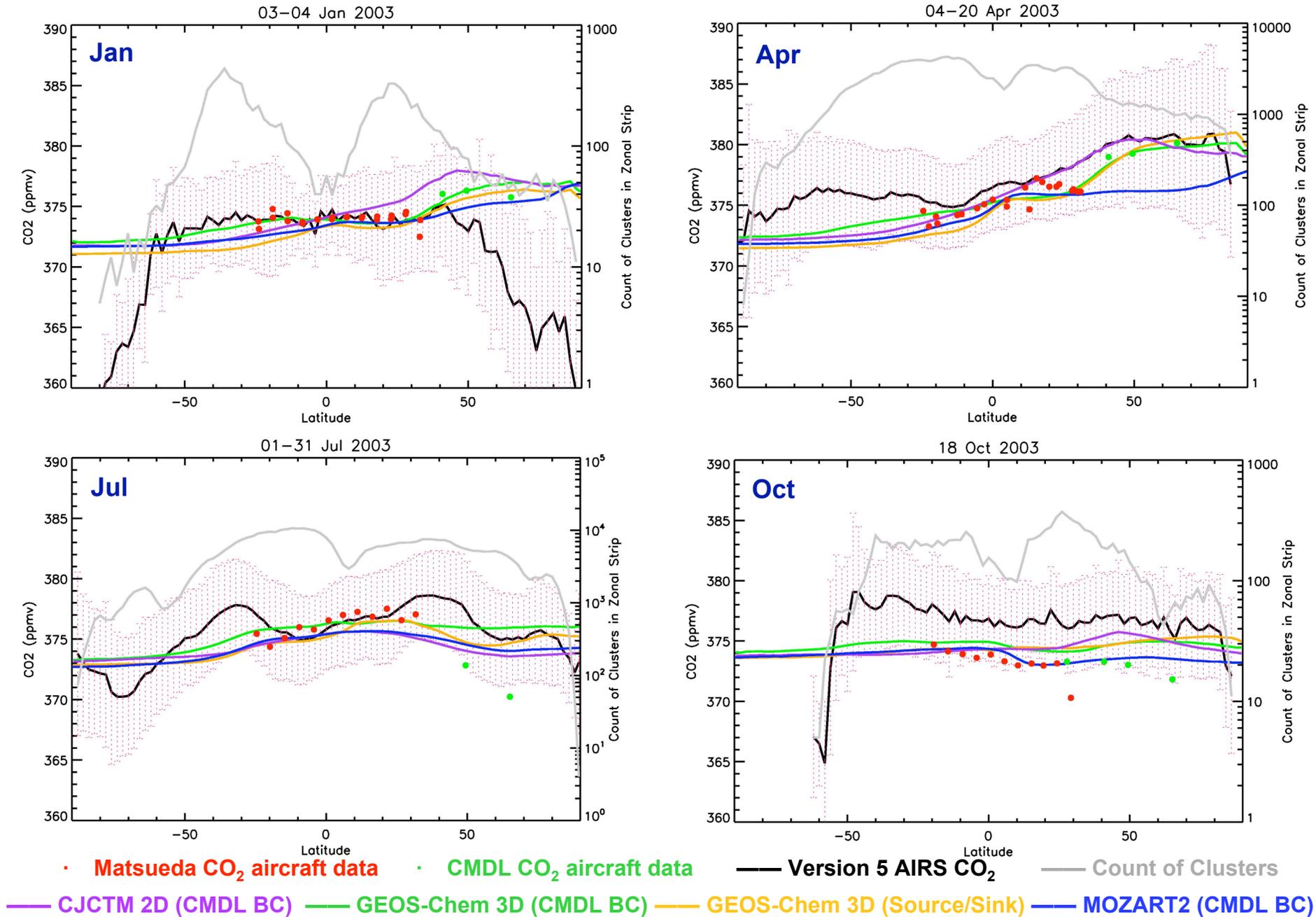
CO<sub>2</sub> retrieved by Vanishing Partial Derivatives (VPD)  
*Chahine et al. [2005, GRL]*

# Version 5 AIRS CO<sub>2</sub>

01-31 Jul 2003

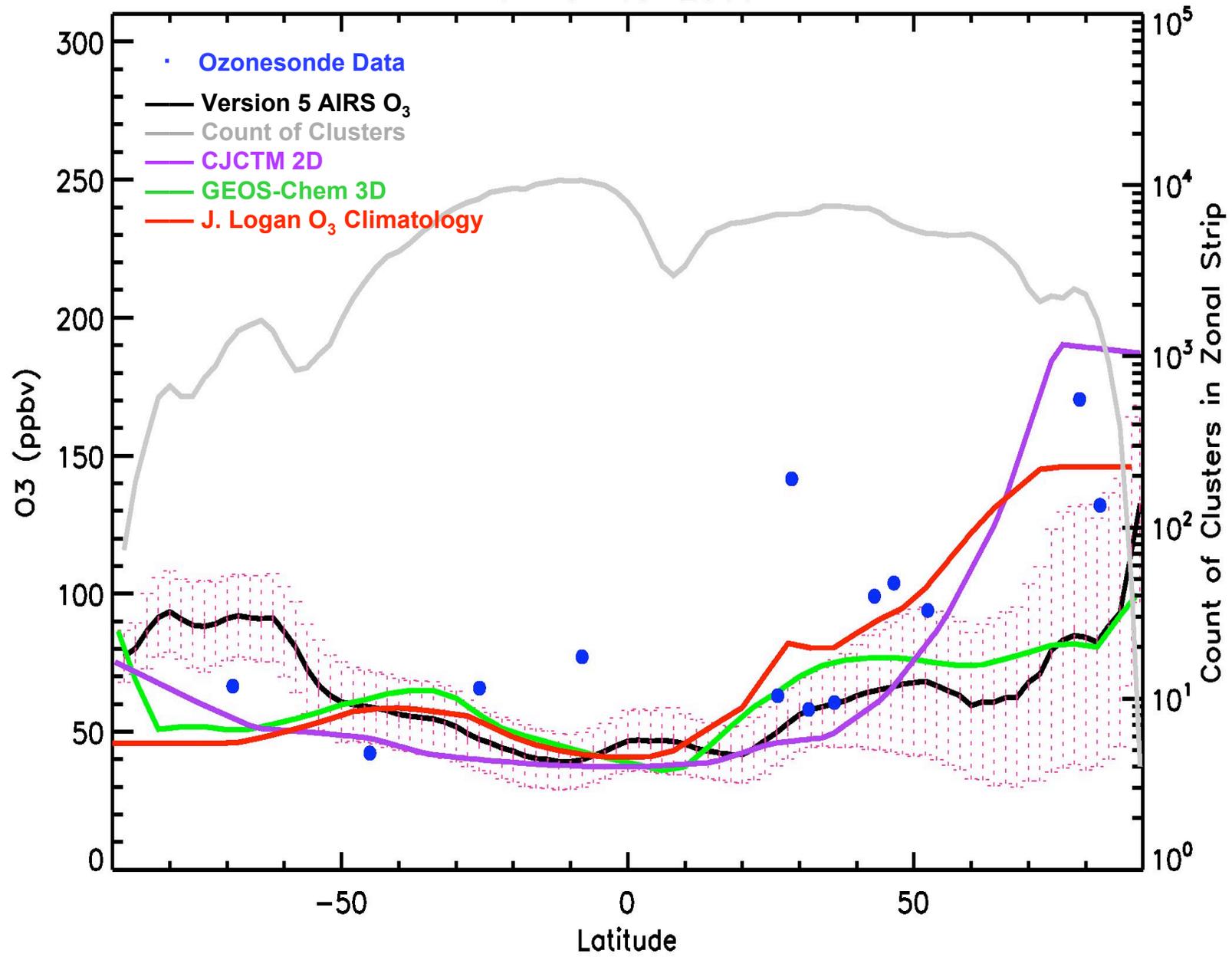


# Version 5 AIRS CO<sub>2</sub>

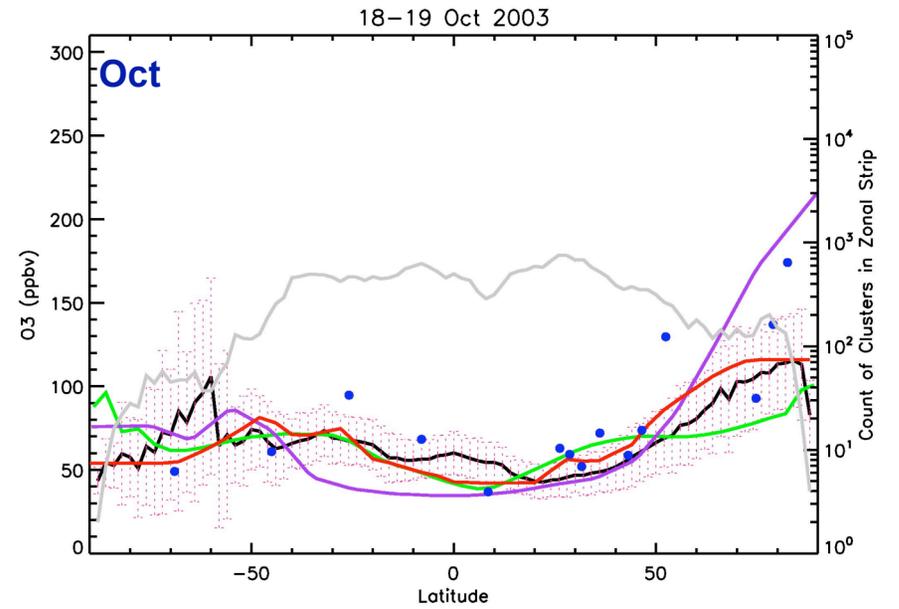
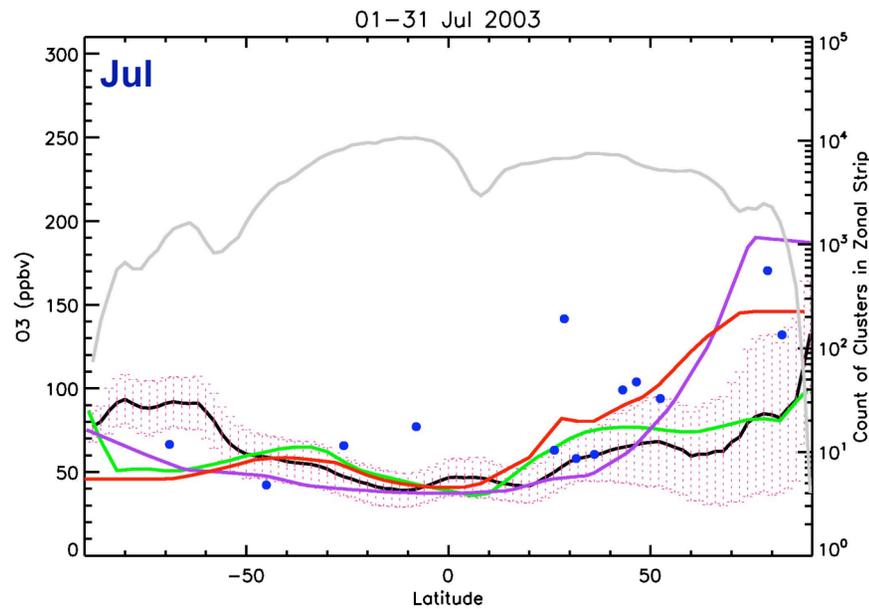
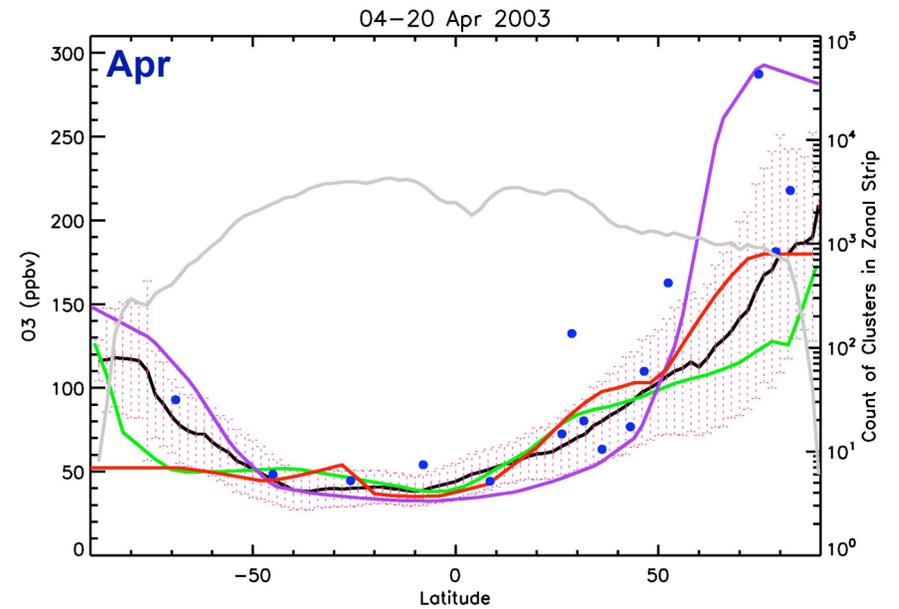
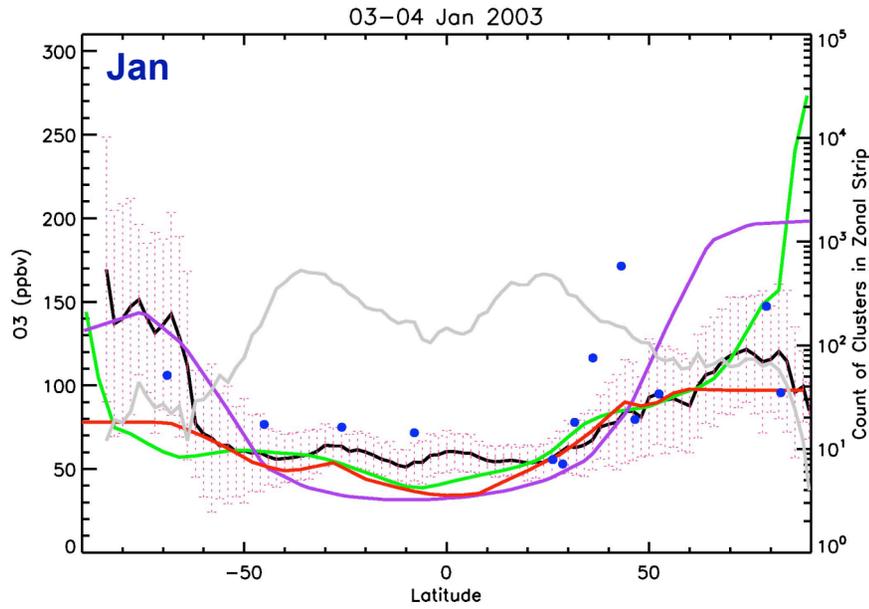


# Version 5 AIRS O<sub>3</sub>

01-31 Jul 2003



# Version 5 AIRS O<sub>3</sub>

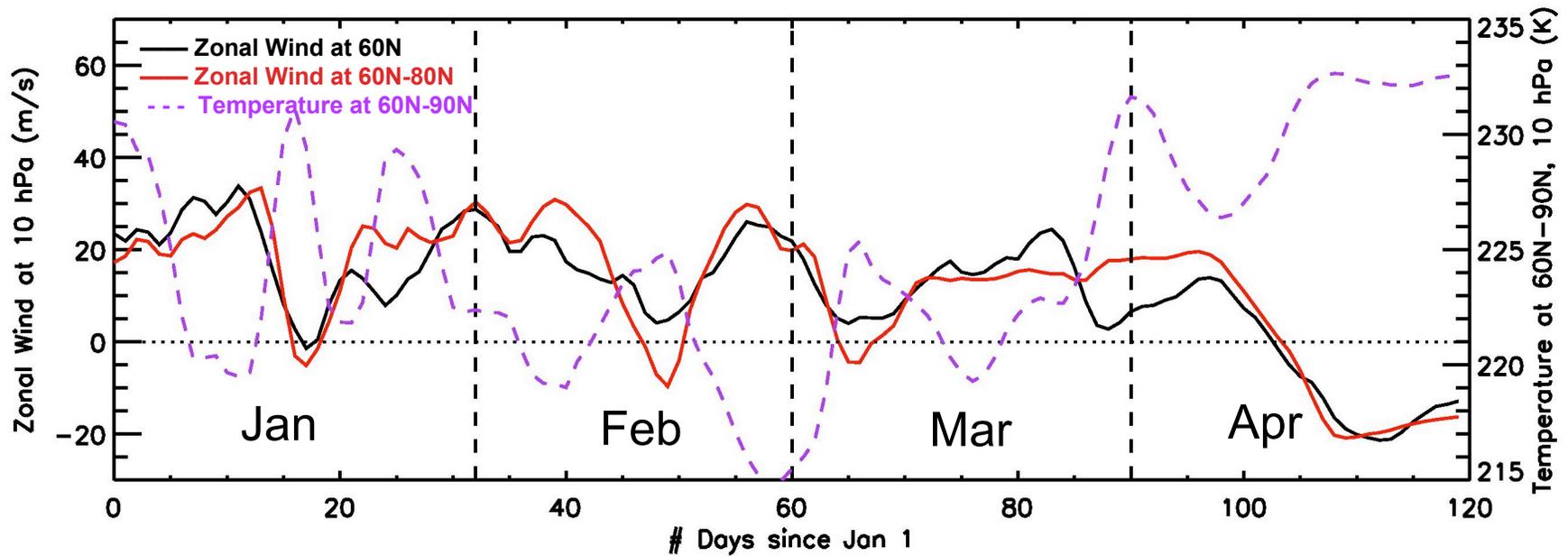


· Ozone sonde Data  
— CJCTM 2D

— Version 5 AIRS O<sub>3</sub>  
— GEOS-Chem 3D

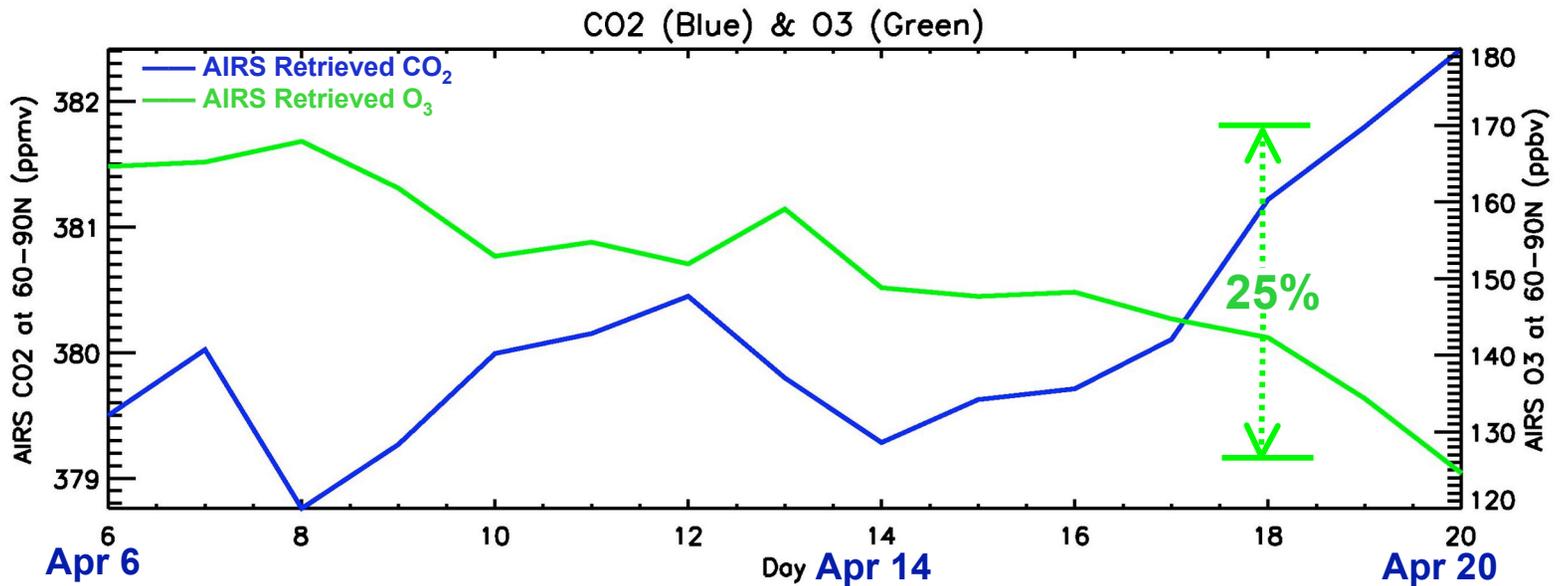
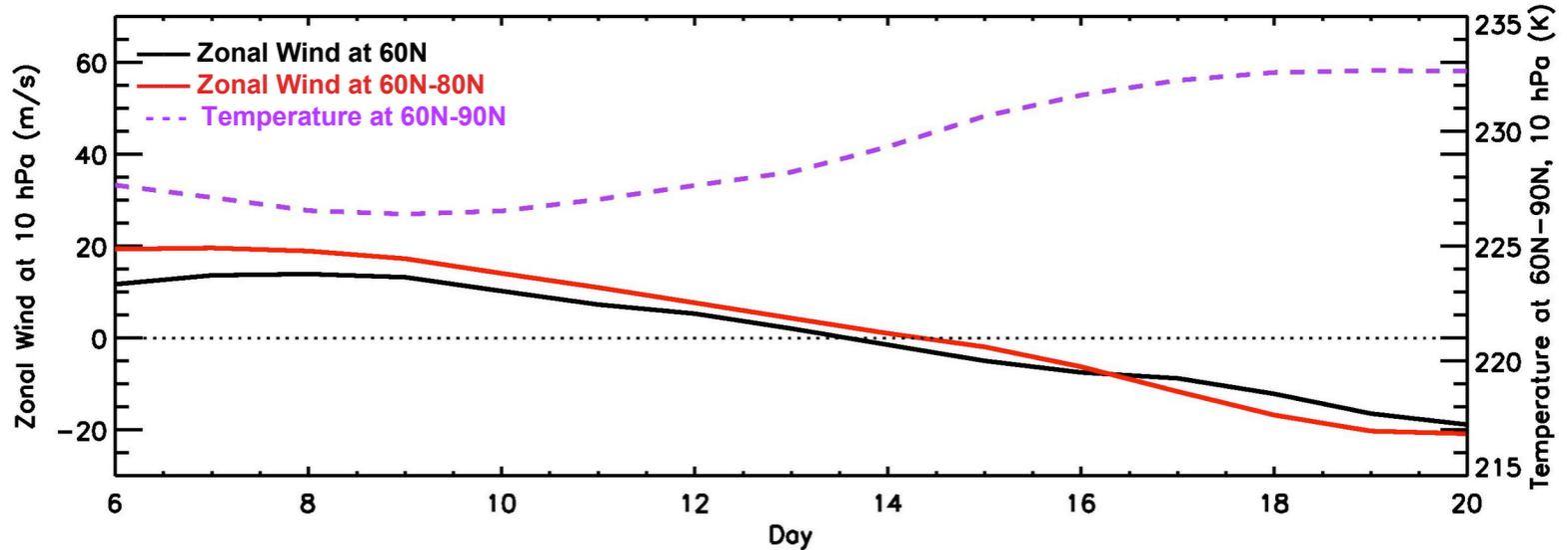
— Count of Clusters  
— J. Logan O<sub>3</sub> Climatology

# Northern Hemisphere Stratospheric Sudden Warming



- Stratospheric Major Warming Criteria: averaged 60-80°N zonal mean winds and 60°N zonal mean wind reverse sign [Manney et al., 2005].
- It has important influence on the chemical tracers.

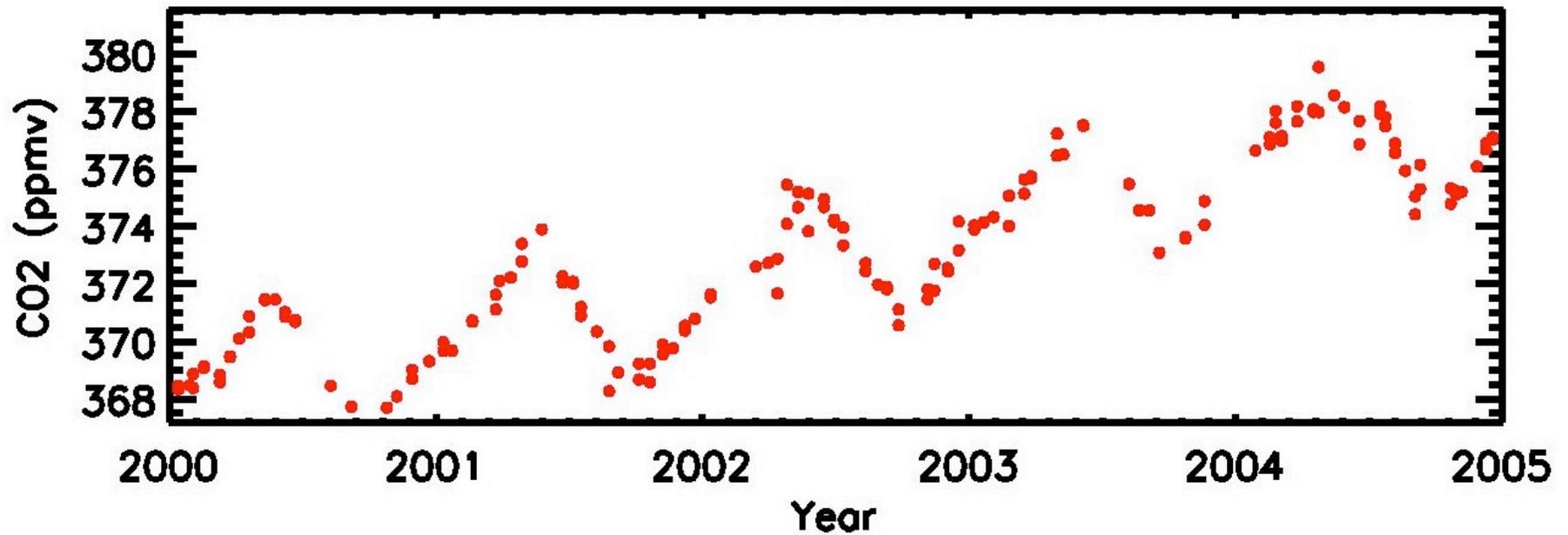
# Influence of Sudden Warming on CO<sub>2</sub> and O<sub>3</sub>



AIRS retrieved upper tropospheric CO<sub>2</sub> increases while AIRS 300 mb O<sub>3</sub> decreases following a sudden stratospheric warming event

# Comparison of Model CO<sub>2</sub> with Matsueda Aircraft Data

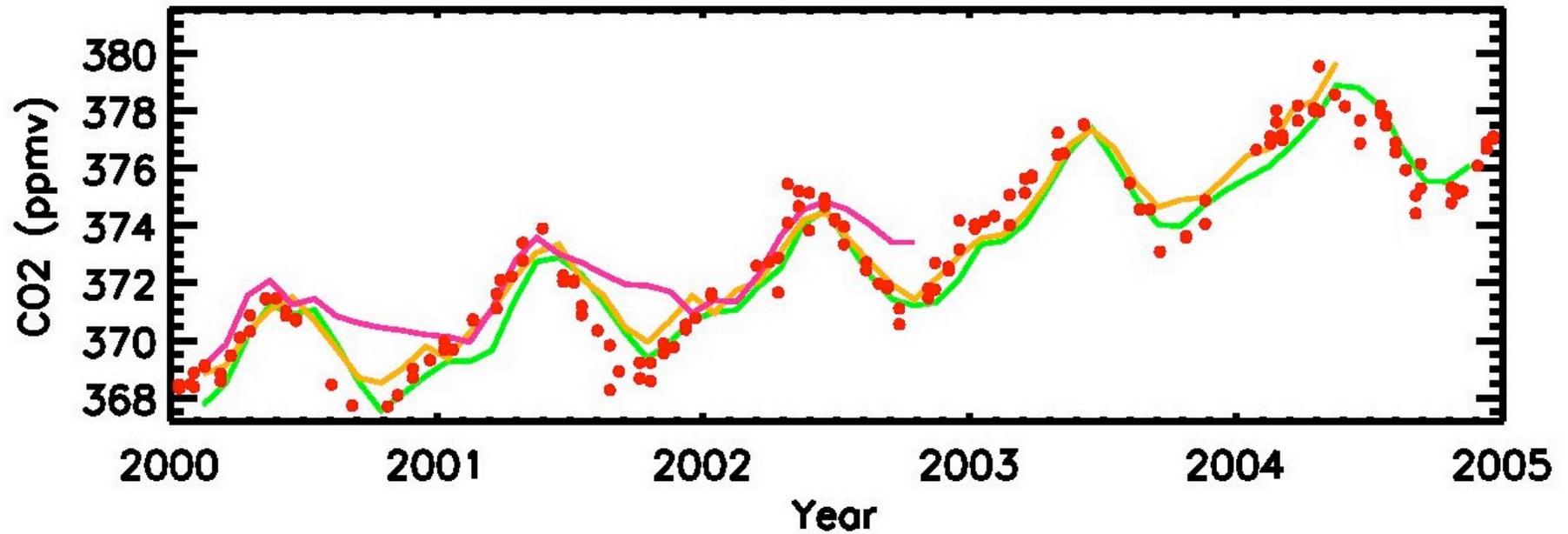
Lon:150.0; Lat: 15



· Matsueda CO<sub>2</sub> aircraft data

# Comparison of Model CO<sub>2</sub> with Matsueda Aircraft Data

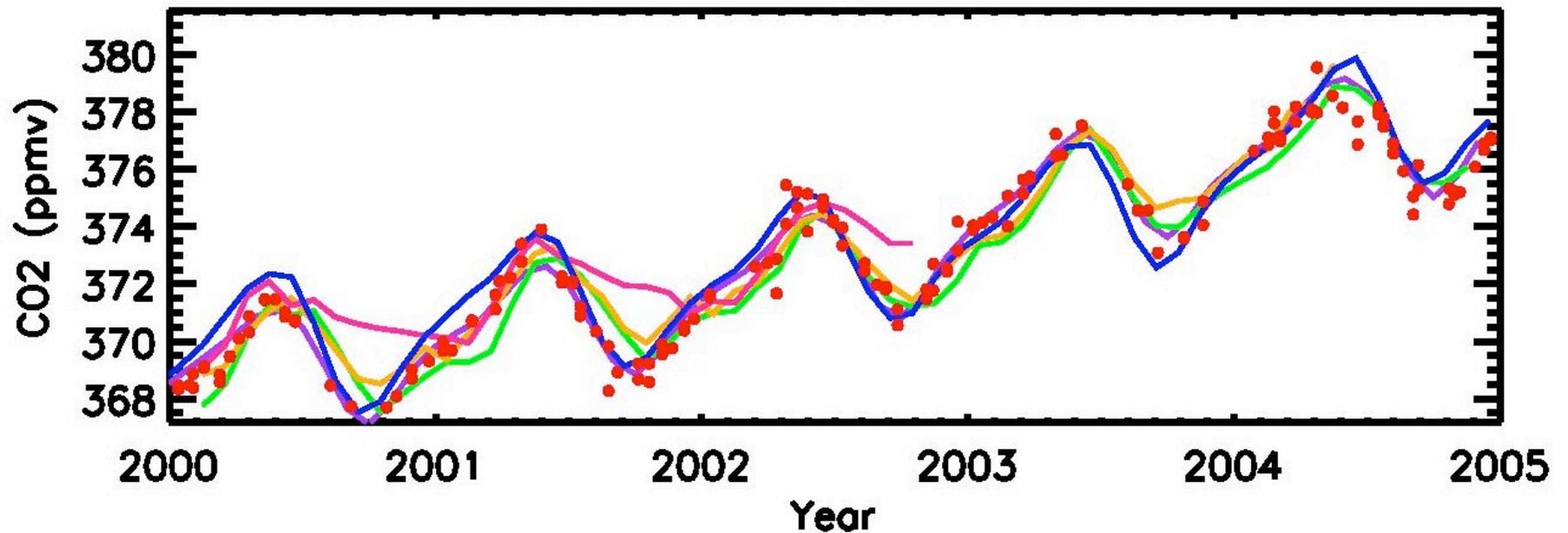
Lon:150.0; Lat: 15



- Matsueda CO<sub>2</sub> aircraft data
- GEOS-Chem 3D (CMDL BC)
- GEOS-Chem 3D (Source/Sink)
- GEOS-Chem 3D; GEOS-3 (CMDL BC)

# Comparison of Model CO<sub>2</sub> with Matsueda Aircraft Data

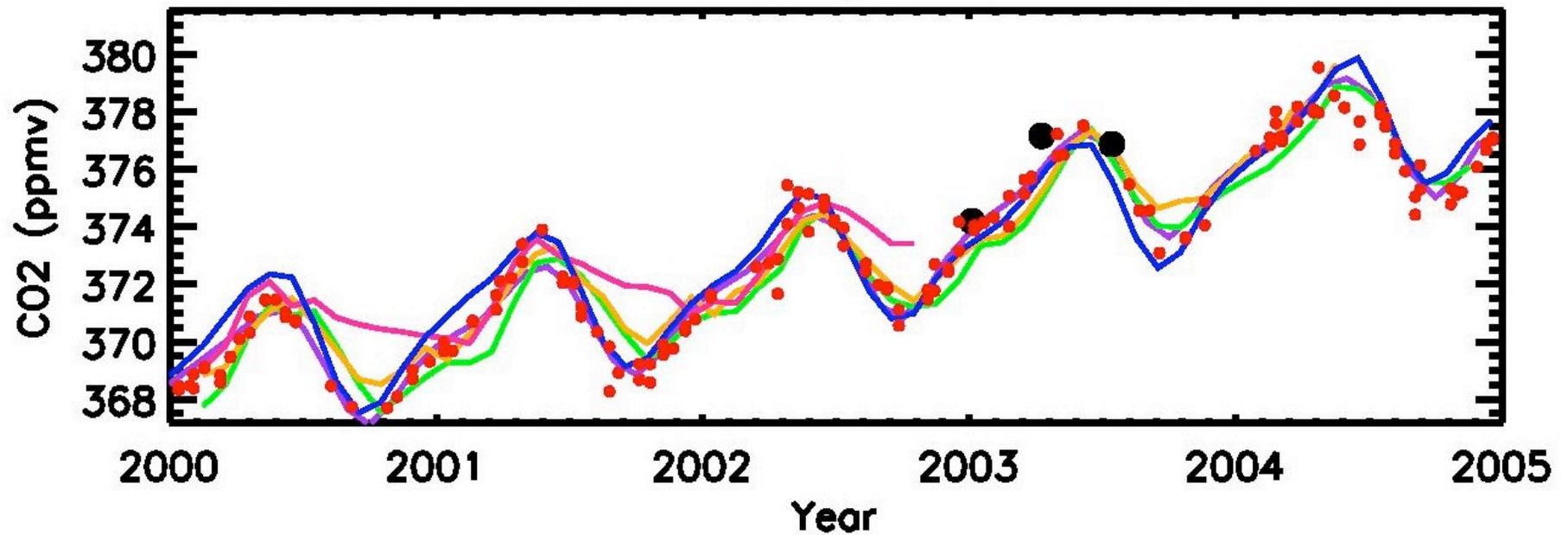
Lon:150.0; Lat: 15



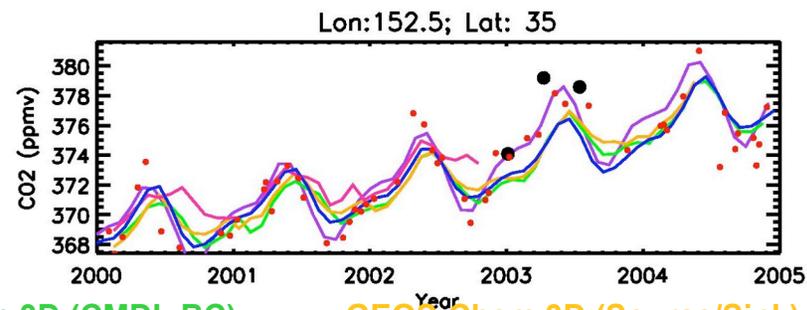
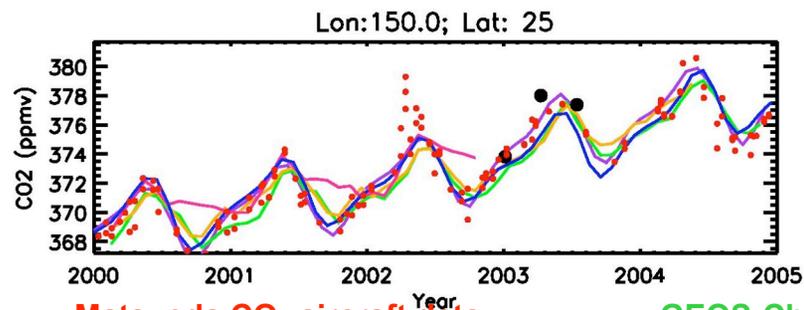
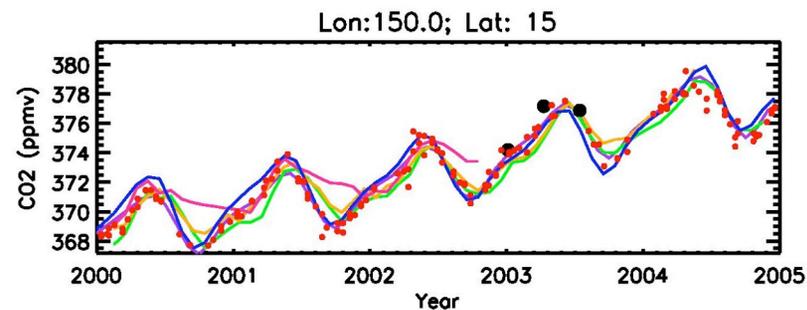
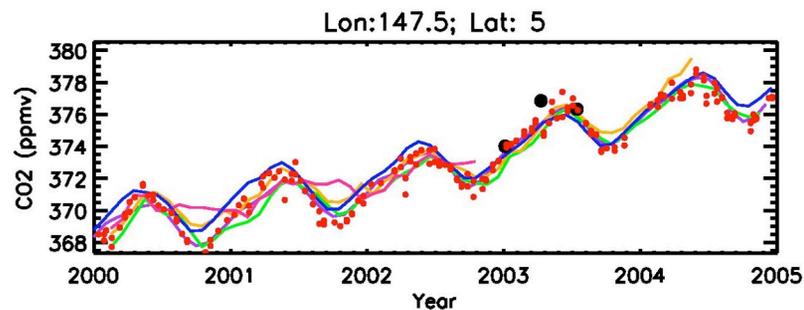
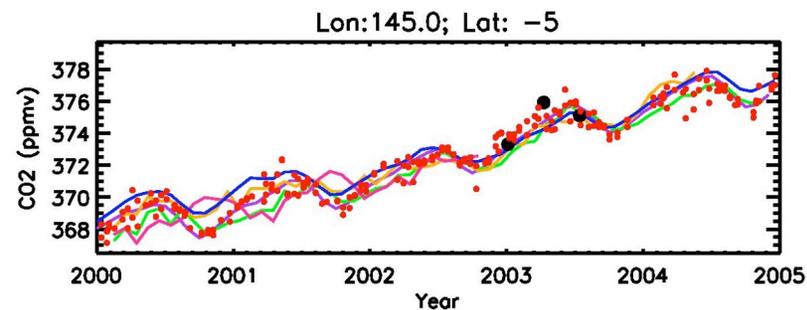
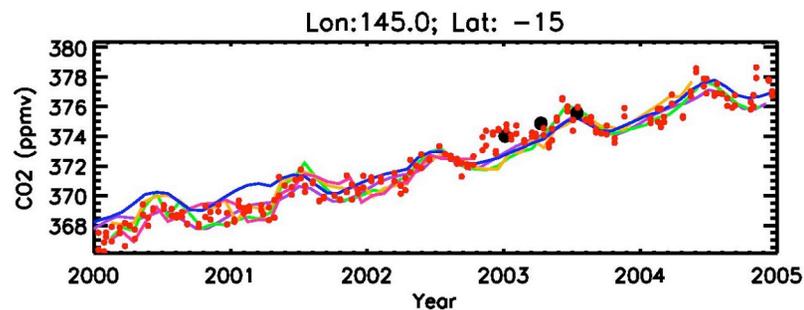
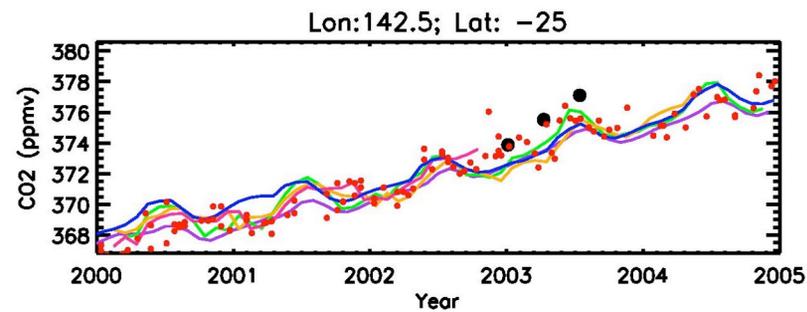
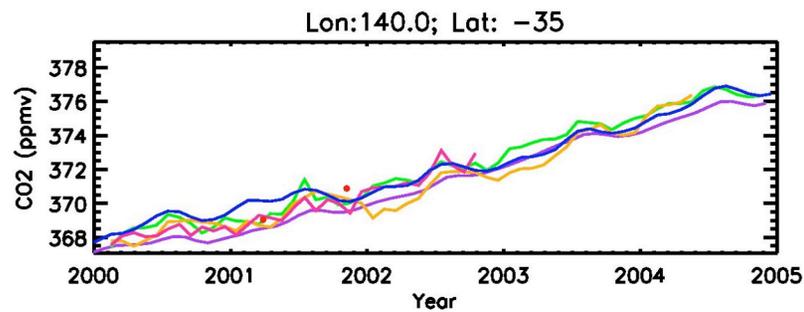
- Matsueda CO<sub>2</sub> aircraft data
- GEOS-Chem 3D (CMDL BC)
- GEOS-Chem 3D (Source/Sink)
- GEOS-Chem 3D; G-3 (CMDL BC)
- CJCTM 2D (CMDL BC)
- MOZART2 (CMDL BC)

# Comparison of Model CO<sub>2</sub> with AIRS CO<sub>2</sub>

Lon:150.0; Lat: 15



- Matsueda CO<sub>2</sub> aircraft data
- GEOS-Chem 3D (CMDL BC)
- GEOS-Chem 3D (Source/Sink)
- GEOS-Chem 3D; G-3 (CMDL BC)
- CJCTM 2D (CMDL BC)
- MOZART2 (CMDL BC)
- Version 5 AIRS CO<sub>2</sub>



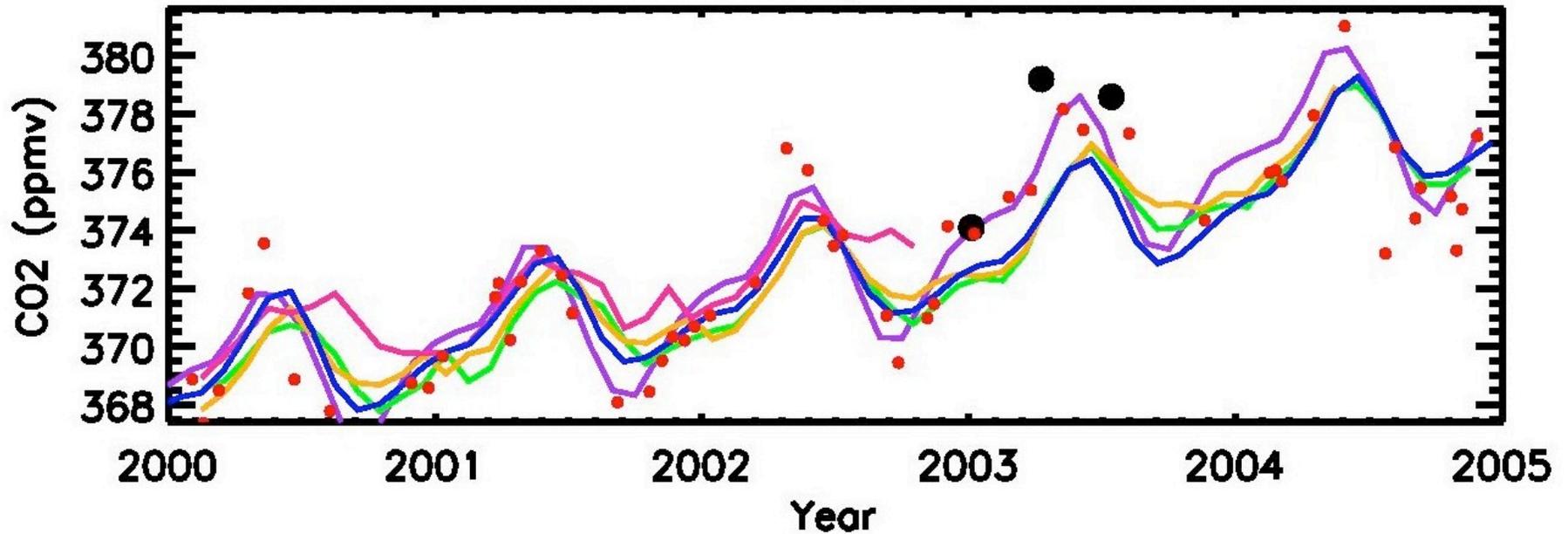
· Matsueda CO<sub>2</sub> aircraft data    
 — GEOS-Chem 3D (CMDL BC)    
 — GEOS-Chem 3D (Source/Sink)

— GEOS-Chem 3D; G-3 (CMDL BC)    
 — CJCTM 2D (CMDL BC)    
 — MOZART2 (CMDL BC)

· Version 5 AIRS CO<sub>2</sub>

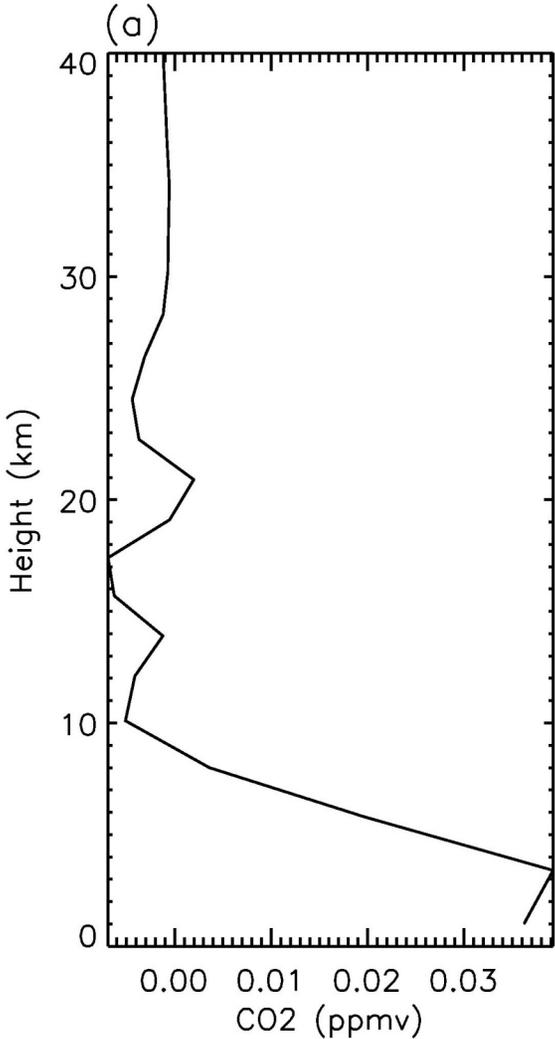
# Vertical Transport in Models

Lon: 152.5; Lat: 35

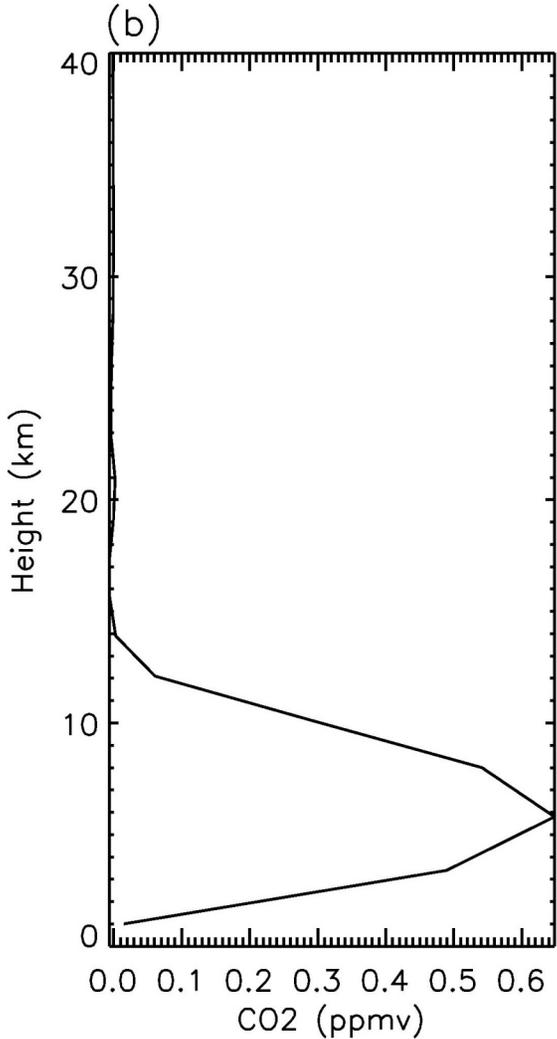


- Matsueda CO<sub>2</sub> aircraft data
- GEOS-Chem 3D (CMDL BC)
- GEOS-Chem 3D (Source/Sink)
- GEOS-Chem 3D; G-3 (CMDL BC)
- CJCTM 2D (CMDL BC)
- MOZART2 (CMDL BC)
- Version 5 AIRS CO<sub>2</sub>

# Sensitivity Studies



Effect of Turbulence  
Mixing in PBL



Effect of Deep Convection  
Updraft Mass Flux



National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

*Atmospheric Infrared Sounder*

## Conclusions

- The latitudinal distribution of AIRS retrievals of upper tropospheric CO<sub>2</sub> agrees reasonably well with model calculations and in situ aircraft observations of CO<sub>2</sub> from 50°S to 50°N.
- Model calculations and AIRS retrievals of CO<sub>2</sub> capture the seasonal cycle.
- AIRS retrieved O<sub>3</sub> at 300 hPa agrees reasonably well with ozonesonde measurements and model calculations.
- AIRS retrieved upper tropospheric CO<sub>2</sub> increases while AIRS 300 mb O<sub>3</sub> decreases following a sudden stratospheric warming event.
- The convective mass flux is crucial for the correct simulation of upper tropospheric CO<sub>2</sub>.



National Aeronautics and  
Space Administration

**Jet Propulsion Laboratory**  
California Institute of Technology  
Pasadena, California

*Atmospheric Infrared Sounder*

*Thank you!*